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## EXPERIENCES WITH ICE IN STANDPIPES<sup>1</sup>

BY LEONARD METCALF<sup>2</sup>

Some time ago the author was confronted with the question as to whether it was necessary or not to house standpipes in northern New York, under certain conditions of exposure and circulation, in order to maintain satisfactory service without dangerous risk from the effect of the formation of ice in them. The housing of the standpipe bade fair to nearly double its cost, and the tremendous increase in the cost of water works construction of all kinds, particularly of steel structures, made it necessary to save expense in every desirable way.

It was thought that past experience with such structures in the northern United States and in southern Canada might furnish an answer to some of the important practical questions involved, and aid in reaching a sound conclusion. Therefore a questionnaire was sent out (February 18, 1920) to about 300 northern water works having standpipes, relative to their past experiences in operating them during the cold winter months. The response of the superintendents to this questionnaire has been so prompt and courteous, and the experience outlined is so suggestive, that the author has thought it desirable to bring the assembled information before the water works fraternity, for the convenience of these men, and other superintendents and engineers who may be interested in the subject, in the form of a permanent record available to all.

The replies received have been classified in the accompanying tables in three groups under two main classes as follows:

- Group Ia.* Ground water supplies with encased standpipes
- Group Ib.* Ground water supplies with roofed standpipes
- Group Ic.* Ground water supplies with uncovered standpipes
- Group IIa.* Surface water supplies with encased standpipes
- Group IIb.* Surface water supplies with roofed standpipes
- Group IIc.* Surface water supplies with uncovered standpipes

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<sup>1</sup> Discussions of this paper are desired and should be sent to the Editor.

<sup>2</sup> Of Metcalf & Eddy, Consulting Engineers, 14 Beacon Street, Boston, Mass.

It is to be noted unfortunately that the question as to whether the supplies were drawn from the ground or from the surface, was inadvertently omitted from the questionnaire, and that lacking time to recanvass the situation, this information was drawn from the "McGraw Water Works Directory" (1915).

The reasons for the grouping adopted are obvious. Ground water is generally more equable in temperature, colder in summer and warmer in winter, than is water obtained from surface sources. The three groups, "encased," "roofed" and "uncovered," were thought likely to differentiate the effect of covering the standpipe.

One hundred and twenty-seven replies were received, falling within the following groups:<sup>3</sup>

|  |     |
|--|-----|
| <i>Group Ia.</i> Ground water with encased standpipes.....     | 5   |
| <i>Group Ib.</i> Ground water with roofed standpipes.....      | 39  |
| <i>Group Ic.</i> Ground water with uncovered standpipes.....   | 23  |
|  | —   |
| Total ground water supplies.....                               | 67  |
| <i>Group IIa.</i> Surface water with encased standpipes.....   | 9   |
| <i>Group IIb.</i> Surface water with roofed standpipes.....    | 11  |
| <i>Group IIc.</i> Surface water with uncovered standpipes..... | 40  |
|  | —   |
| Total surface water supplies.....                              | 60  |
|  | —   |
| <i>Grand total</i> replies received.....                       | 127 |

#### SUPPLEMENTARY INFORMATION SUBMITTED WITH REPLIES TO THE QUESTIONNAIRES

*Long Beach Water, Company, New York; L. W. F. Carstein, Manager.* In general our experience leads us to infer that heavy ice formations will occur within the standpipe. The tumbling of ice is frequently heard. It would seem that with the constant lowering and raising of the water level, together with occasional thaws, the ice formation cracks and breaks up and tumbles to a lowered water level. No damage or annoyance, however, has been experienced therefrom. The writer would expect to find by actual observation, that a heavier ice formation would be found on the north and westerly exposure than on the southern exposure, owing to the prevailing northwesterly winds, and again to the moderating action of the sun's rays during the total period of sunlight.

*Winchester Water Commission, Massachusetts; William T. Dotten, Superintendent.* We have two (standpipes). One concrete, built about 8 or 10 years . . . . Ice forms on the walls or sides from 12 to 15 inches. In cold winter five or six years ago we opened in May the manhole at the bottom and removed (estimated) 60 tons of ice. It was a foot thick on the north walls

<sup>3</sup> Later information indicates that certain of the supplies in groups 1A, 1B and 1C should be classified rather as surface waters.

# EXPERIENCES WITH ICE IN

DATA OBTAINED BY METCALF & EDDY, FEB.-MAR. 1920 FROM AND BY THE

| Place                                       | Authority              | Date of construction | Material of Construction | Diameter - Feet | Height - Feet | On ground or on tower. | Height of tower or hill | Location  | Kind of roof                       | Encasing tower | Encased for Architectural purposes |
|---|------------------------|----------------------|--------------------------|-----------------|---------------|------------------------|-------------------------|-----------|------------------------------------|----------------|------------------------------------|
| <b>GROUP 1A. GROUND WATER SUPPLIES WITH</b> |                        |                      |                          |                 |               |                        |                         |           |                                    |                |                                    |
| 1. WEYBURN, SASK.                           | Jas. Scholes, Supt.    | 1910                 | Steel                    | 20              | 80            | Concr. fdn.            |                         | Exposed   | Wood                               | (9)            | No                                 |
| 2. BELDING, N.Y.                            | Jas. Beadell, Supt.    | 1889                 | Wrought iron             | 24              | 30            | Ground                 |                         | Exposed   | Iron                               | (1)            | No                                 |
| 3. OSSINING, N.Y.                           | Jas. Beadell, Supt.    | 1909                 | Reinfr. Concrete         | 26.5            | 55            | Ground                 |                         | Exposed   | Concrete                           | (2)            | No                                 |
| 4. ROUND LAKE, N.Y.                         | J. T. Wilmar.          | 1890                 | Wooden                   | 25              | 15            | Stone Wall             | 8 ft.                   | Exposed   | Wood & Tin (Conc.) Wood Metal clad | (3)            | No                                 |
| 5. NORTH BATTLEFORD, SASK.                  | M.D. Cadwell, Supt.    | 1909                 | Steel                    | 20              | 80            | Ground                 |                         | Exposed   |                                    | (4)            | No                                 |
| <b>GROUP 1B. GROUND WATER SUPPLIES WITH</b> |                        |                      |                          |                 |               |                        |                         |           |                                    |                |                                    |
| 1. NEWAGO, MICH.                            | G.M. Burner, Supt.     | 1913                 | Wooden                   | 20              | 18            | Tower                  | 85 ft.                  | In Open   | Shingles                           |                | No                                 |
| 2. BELDING, MICH.                           | P.A. Frederick, Supt.  | 1905                 | Steel                    | 20              | 38            |                        | 80 ft.                  | In Open   | Shingles                           |                | No                                 |
| 3. DUXBURY, MASS.                           | L.M. Peterson, Supt.   | 1914                 | Concrete                 | 40              | 35            | Ground                 | 30 ft.                  | Exposed   | Concr. Dome                        | None           | No                                 |
| 4. FERGUS, ONT.                             | Water Dept.            | 1912                 | Steel                    | 19              | 21            | Tower                  | 90 ft.                  | Exposed   | Iron                               | None           | No                                 |
| 5. CHERRY VALLEY-ROCHDALE, MASS.            | Water Dist.            | 1910                 | Concrete                 | 40              | 21            | Ground                 |                         | Exposed   | Concrete                           |                | No                                 |
| 6. REEDSBURG, WIS.                          | Water Dept.            | 1900                 | Steel                    | 20.5            | 85            | Brick base             | 59 ft.                  | Exposed   | Steel                              |                | No                                 |
| 7. LANSING, MICH.                           | Water Dept.            | 1885                 | Steel                    | 18              | 152           | Ground                 |                         | Exposed   | Wooden                             |                | No                                 |
| 8. MUSKINGE HEIGHTS, MICH.                  | H.G. Cohen, City Eng.  | 1908                 | Steel                    | 16              | 125           | Ground                 |                         | Exposed   | Steel Metal                        |                | No                                 |
| 9. CASS LAKE, MICH.                         | Water Dept.            | 1910                 | Steel                    | 20              | 30            | Tower                  | 100 ft.                 | Exposed   | Steel                              | Riser Encased  | No                                 |
| 10. WRENTHAM, MASS.                         | Water Dept.            | 1907                 | Steel                    | 30              | 50            | Ground                 |                         | Exposed   | Steel                              |                | No                                 |
| 11. MILFORD, MASS.                          | J. Win. Kay, Supt.     | 1912                 | Steel                    | 24              | 30            | Ground                 |                         | Exposed   | Steel                              |                | No                                 |
| 12. WINCHESTER, MASS.                       | W.T. Dohen, Supt.      | 1910                 | Concrete                 | 27              | 40            | Cement fdn.            |                         | In Trees  | Steel                              | None           | No                                 |
| 13. PLAINVILLE, MASS.                       | Water Dept.            | 1908                 | Steel                    | 25              | 67            | Tower                  |                         | Exposed   | Sheet Iron                         | Riser Encased  | No                                 |
| 14. UBY, MICH.                              | Water Dept.            | 1915                 | Steel                    | 20              | 30            | Ground                 | 75 ft.                  | Exposed   | Wood covered with tin              |                | No                                 |
| 15. BROOKLINE, MASS.                        | Water Dept.            | 1889                 | Wrought iron             | 50              | 30            | Ground                 |                         | Exposed   | Conc. Iron                         |                | No                                 |
| 16. READING, MASS.                          | L.M. Bancroft, Supt.   | 1890                 | Wrought iron             | 30              | 100           | Ground                 |                         | Exposed   | Shingles                           |                | No                                 |
| 17. AMENIA, N.Y.                            | Water Dept.            | 1891                 | Wooden                   | 24              | 24            | Ground                 |                         | Exposed   | Shingles                           |                | No                                 |
| 18. BEDFORD, MASS.                          | G.M. Diamond, Supt.    | 1908                 | Steel                    | 20              | 100           | Concr. fdn.            | 7 ft.                   | Exposed   | Wooden                             |                | No                                 |
| 19. MARSHALL, MASS.                         | P.S. Joy, Supt.        | 1890                 | Steel                    | 20              | 100           | Ground                 |                         | In Open   | Shingles and weathering water      |                | No                                 |
| 20. FRAMINGHAM, MASS.                       | Water Dept.            | 1898                 | Steel                    | 40              | 81            | Ground                 |                         | Exposed   | Steel                              |                | No                                 |
| 21. BALDWINVILLE, MASS.                     | Ezra Cole, Supt.       | 1889                 | Wrought iron             | 20              | 50            | Ground                 |                         | Exposed   | Klar Roof                          | None           | No                                 |
| 22. ORILLIA, ONT.                           | Water Dept.            | 1900                 | Wooden                   | 18              | 20            | Brick Tower            | 40 ft.                  | In Open   | Conical Wood                       | None           | No                                 |
| 23. BATTLE CREEK, MICH.                     | Water Dept.            | 1887                 | Wrought iron             | 18              | 75            | Terrace                | 6 ft.                   | In Open   | Sheet Iron                         | None           | No                                 |
| 24. RIVERHEAD, N.Y.                         | Water Dept.            | 1915                 | Steel                    | 18              | 75            | Tower                  | 180 ft. Uncl. tank      | Exposed   | Steel                              |                | No                                 |
| 25. ASHLAND, MASS.                          | Water Dept.            | 1911                 | Concrete                 | 40              | 31            | Ground                 |                         | In Open   | Cement                             |                | No                                 |
| 26. NORTH ATTLEBORO, MASS.                  | Water Dept.            | 1884                 | Wrought iron             | 40              | 60            | Ground                 | 60 ft.                  | In Open   | Conc. Steel                        | None           | No                                 |
| 27. MAUPOSETT, MASS.                        | Water Dept.            | 1913                 | Steel                    | 25              | 90            | Ground                 |                         | In Open   | Shingles                           | None           | No                                 |
| 28. SAUATUCK, MICH.                         | Water Dept.            | 1908                 | Concrete                 | 25              | 105           | Tower                  |                         | In Open   | Steel                              | None           | No                                 |
| 29. BARNESVILLE, MINN.                      | H.H. Perce, Supt.      | 1908                 | Steel                    | 34              | 150           | Concrete fdn.          | 3 ft.                   | Exposed   | Cone shaped                        | None           | No                                 |
| 30. LONG BEACH, N.Y.                        | L.W. Carstein, Mgr.    | 1909                 | Concrete                 | 50              | 72            | Ground                 |                         | In Open   | Gustave Tie                        | None           | No                                 |
| 31. MANCHESTER-BY-THE-SEA, MASS.            | G.E. Evans, Supt.      | 1911                 | Steel                    | 35              | 40            | Ground                 |                         | In Trees  | Steel Pith                         | None           | No                                 |
| 32. LITTLETON, MASS. (MASS.)                | Water Dept.            | 1909                 | Steel                    | 24              | 28            | Tower                  | 137 ft.                 | Exposed   | Wood                               | Riser Encased  | No                                 |
| 33. CLOQUET, MINN.                          | Water Dept.            | 1890                 | Steel                    | 20              | 38            | Brick fdn.             |                         | Exposed   | Shingle                            | None           | No                                 |
| 34. LAKE GENEVA, MICH.                      | W. O'Neil, Supt.       | 1890                 | Wooden                   | 20              | 38            | Brick fdn.             |                         | Exposed   | Steel                              | None           | No                                 |
| 35. WATERLOO, WIS.                          | Water Dept.            | 1895                 | Steel                    | 18              | 80            | Ground                 | 30 ft. (90 ft. tank)    | Exposed   | Wrought iron                       | Riser Encased  | No                                 |
| 36. MONUMENT BEACH, MASS.                   | T. Chaffin, Supt.      | 1916                 | Steel                    | 20              | 100           | Tower                  | 100 ft. (90 ft. tank)   | Exposed   | Steel                              | None           | No                                 |
| 37. ELMIRA, ONT.                            | Water Dept.            | 1909                 | Steel                    | 16              | 18            | Tower                  | 120 ft.                 | In Open   | Steel                              | Riser Encased  | No                                 |
| 38. BANGOR, MICH.                           | Water Dept.            | 1893                 | Steel                    | 22              | 28            | Tower                  |                         | Exposed   | Steel                              | Riser Encased  | No                                 |
| 39. SPENCERPORT, N.Y.                       | Water Dept.            |                      | Steel                    | 22              | 28            | Tower                  |                         | Exposed   | Steel                              | Riser Encased  | No                                 |
| <b>GROUP 1C. GROUND WATER SUPPLIES WITH</b> |                        |                      |                          |                 |               |                        |                         |           |                                    |                |                                    |
| 1. BOYNE CITY, MICH. 1.                     | H.N. Tinker, Supt.     | 1906                 | Concrete                 | 86              | 150           | Ground                 | 215 ft. hill            | Exposed   | Two Open, One Wood                 | None           | No                                 |
| 2. BOYNE CITY, MICH. 2.                     | H.N. Tinker, Supt.     | 1906                 | Concrete                 | 30              | 60            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 3. BOYNE CITY, MICH. 3.                     | H.N. Tinker, Supt.     | 1906                 | Concrete                 | 30              | 60            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 4. NEW ROCHELLE, N.Y.                       | F.T. Kerns, Supt.      | 1895                 | Steel                    | 60              | 60            | Ground                 | 30 ft. hill             | Exposed   | None                               | None           | No                                 |
| 5. SHARON, MASS.                            | E.E. Farnham, Supt.    | 1885                 | Wrought iron             | 20              | 80            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 6. LOCKPORT, N.Y.                           | Water Dept.            | 1909                 | Steel                    | 25              | 126           | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 7. AMITYVILLE, N.Y.                         | Water Dept.            | 1893                 | Wrought iron             | 20              | 125           | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 8. SPENCER, MASS.                           | Water Dept.            | 1899                 | Steel                    | 40              | 39            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 9. BRAintree, MASS.                         | W.L. Gage              | 1897                 | Wrought iron             | 40              | 100           | Ground                 | 6 ft.                   | In Trees  | None                               | None           | No                                 |
| 10. CORTLAND, N.Y.                          | Water Dept.            | 1911                 | Ingr. Iron               | 60              | 50            | Concrete fdn.          |                         | Exposed   | None                               | None           | No                                 |
| 11. TISBURY, MASS.                          | W.E. Howard, Supt.     | 1885                 | Wrought iron             | 20              | 50            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 12. WOLCOTT, N.Y.                           | B.J. Christian, Supt.  | 1912                 | Steel                    | 15              | 85            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 13. ANN ARBOR, MICH.                        | R. Spokes, Supt.       | 1916                 | Steel                    | 30              | 60            | Tower                  |                         | In Open   | None                               | None           | No                                 |
| 14. MOHAWK, N.Y.                            | Water Dept.            | 1890                 | Steel                    | 18              | 50            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 15. MANISTEE, MICH.                         | Water Dept.            | 1912                 | Steel                    | 45              | 55            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 16. BROOKLYN, N.Y. Flatbush W.W. Co.        | E.H. Lott, Supt.       | 1881                 | Steel                    | 20              | 101           | Ground                 | 80 ft. hill             | Exposed   | None                               | None           | No                                 |
| 17. NANTUCKET, MASS.                        | Wannacomet W. Co.      | 1908                 | Steel                    | 30              | 80            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 18. KALISPELL, MONT.                        | M.H. Lawrence, Supt.   | 1892                 | Steel                    | 25              | 50            | Concrete fdn.          |                         | Sheltered | None                               | None           | No                                 |
| 19. RIFON, WIS.                             | Cent. W. Utilities Co. | 1895                 | Wrought iron             | 15              | 100           | Ground                 |                         | In Open   | None                               | None           | No                                 |
| 20. WAUKESHA, WIS.                          | B.B. Hallford, Supt.   | 1897                 | Steel                    | 35              | 40            | Ground                 | 128 ft.                 | In Open   | None                               | None           | No                                 |
| 21. WINGHAM, MASS.                          | W.T. Dohen, Supt.      | 1898                 | Steel                    | 40              | 76            | Leads                  | 1 ft.                   | In Trees  | None                               | None           | No                                 |
| 22. BARABOA, WIS.                           | Water Dept.            | 1888                 | Steel                    | 30              | 55            | Ground                 |                         | Exposed   | None                               | None           | No                                 |
| 23. FRANKLIN, MASS.                         | F.A. Darling, Supt.    | 1889                 | Iron                     | 37              | 80            | Ground                 |                         | Exposed   | None                               | None           | No                                 |

(1) 12" brick tower 2 ft. between wall and tank. (2) Rubble wall 2' 9" thick at base; 15" to 20" at top; 12" air space. (3) Masonry fill. (4) Wood stave, with fire morning and evening when temperature is below zero. (5) Small radiator in bottom of standpipe all winter. (6) Lumber with 2 ft. air space. (7) Cost of casing about 30% of whole.

\* Later information indicates that certain of the supplies in Groups 1A, 1B and 1C show

1920 FROM AND BY THE COURTESY OF THE WATER WORKS SUPERINTENDENTS.

ER SUPPLIES WITH ENCASED STANDPIPES.\*

### WATER SUPPLIES WITH ROOFED STANDPIPES. \*

### LATER SUPPLIES WITH UNCOVERED STANDPIPES

1/4" SPACE (3) Masonry filled in with hay and 2 ft. air chamber. (4) Double wooden sheeting and tar paper; 2 ft. air space.  
bottom of standpipe all winter. (5) Kerosene stove for electric valve (6) 5 ft. to 8 ft. after every thaw.

# EXPERIENCES WITH ICE IN

DATA OBTAINED BY METCALF & EDDY, FEB.-MAR. 1920 FROM AND BY THE C.

| Place   | Authority                 | Date of Construction | Material of Construction | Diameter - Feet | Height - Feet | On ground or on tower | Height of tower or hill | Location | Kind of roof  | Encasing tower                | Encased for Architectural |
|---|---------------------------|----------------------|--------------------------|-----------------|---------------|-----------------------|-------------------------|----------|---------------|-------------------------------|---------------------------|
| <b>GROUP II A. SURFACE WATER SUPPLIES</b>           |                           |                      |                          |                 |               |                       |                         |          |               |                               |                           |
| 1. BUFFALO, N.Y.                                    | G.A. Anderson, Wat. Com.  | 1909                 | Steel                    | 40              | 85            | Ground                |                         | Exposed  | Wooden        | Brick 12 ft. larger than pipe | Yes                       |
| 2. HAMILTON, N.Y.                                   | G.L. Waldron, Supt.       | 1895                 | Steel                    | 37              | 37.8          | Ground                |                         | Exposed  | Concrete      | Brick 2 ft. from shell        | No                        |
| 3. SYRACUSE, N.Y.                                   | Water Dept.               | 1910                 | Steel                    | 66              | 51            | Ground                |                         | Exposed  | Conc. dome    | (5)                           | No                        |
| 4. MILWAUKEE, Wis. MAIN STA.                        | H. P. Bohman              | 1872                 | Wrought Iron             | 4               | 125           | Ground                |                         | Exposed  | Tin           | Stone tower                   | {                         |
| 5. MILWAUKEE, Wis. BOOSTER STA.                     | H. P. Bohman              | 1886                 | Steel                    | 15              | 173           | Ground                |                         | Exposed  | Tin           | Brick tower                   | {                         |
| 6. ATTLEBORO, MASS.                                 | Water Dept.               | 1905                 | Reinf. Conc.             | 50              | 102           | Ground                |                         | Exposed  | Glutarin tile | (6)                           | {                         |
| 7. EDMONTON, ALBERTA. (?)                           | Water Dept.               | 1906                 | Steel                    | 24              | 36            | Tower                 | 90 ft.                  | Exposed  | Shingles      | Encased in wood               | Partly                    |
| 8. HUMBOLDT, SASK.                                  | C.A. Cutting, Supt.       | 1912                 | Steel                    | 20              | 80            | Cement pier           | 8 ft. 6 in.             | Exposed  | Shingles      | Encased in wood               | (11)                      |
| 9. SASKATOON, SASK.                                 | G.D. Archibald, City Eng. | 1909-10              | Steel                    | 20              | 80            | Conc. found.          | 5 ft.                   | In open  | (1)           | Wood                          | No                        |
| <b>GROUP II B. SURFACE WATER SUPPLIES</b>           |                           |                      |                          |                 |               |                       |                         |          |               |                               |                           |
| 1. ALCONAGO, MICH.                                  | ALEI Lt. & W.W.           | 1903                 | Steel                    | 20              | 60            | Tower                 | 40 ft.                  | Exposed  | Iron          | None                          |                           |
| 2. MENASHA, WIS.                                    | J.H. Miesler, Supt.       | 1903                 | Steel                    | 15              | 60            | Brick tower           | 60 ft.                  | Exposed  | Steel         | None                          |                           |
| 3. PARRY SOUND, ONT.                                | Geo. Murray, Eng.         | 1914                 | Steel                    | 36              | 27            | Tower                 | 50 ft.                  | Exposed  | Iron          | None                          |                           |
| 4. VICTORIA, B.C.                                   | Water Dept.               | 1909                 | Conc. steel lined        | 21-9            | 35            | Tower                 | 70 ft.                  | In open  | Concrete      | Riser encased                 | No                        |
| 5. MANISTIQUE, MICH.                                | H. Erickson, Supt.        | 1908                 | Steel                    | 18              | 20            | Tower                 | 60 ft.                  | Exposed  | Steel         | None                          | No                        |
| 6. STAMBAUGH, MICH.                                 | Water Dept.               | 1908                 | Steel                    | 20              | 20            | Tower                 | 80 ft.                  | Exposed  | Steel         | None                          | No                        |
| 7. WATERLOO, N.Y.                                   | H.S. Kinney, V.P.         | 1913                 | Steel                    | 20              | 50            | Tower                 | 100 ft.                 | Exposed  | Steel         | None                          | No                        |
| 8. FARGO, N.D.                                      | Water Dept.               | 1904                 | Steel                    | 20              | 100           | Conc. base            |                         | Exposed  | Shingle       | None                          | No                        |
| 9. PEEKSKILL, N.Y.                                  | I. G. Roake, Supt.        | 1910                 | Steel                    | 24              | 60            | Ground                |                         | Exposed  | Steel cone    | None                          |                           |
| 10. BROCKTON, MASS. 3 & 4.                          | H. Kingman, Supt.         | 1908                 | Steel                    | 19              | 19-6          | Tower                 | 80 ft. 4 in.            | Exposed  | Wood          | None                          |                           |
| 11. BELLEVILLE, ILL.                                | C.M. Horner               | 1895                 | Steel                    | 23 7/8          | 125           | Ground                |                         | Exposed  | Steel         | None                          |                           |
| <b>GROUP II C. SURFACE WATER SUPPLIES</b>           |                           |                      |                          |                 |               |                       |                         |          |               |                               |                           |
| 1. ALEXANDRIA BAY, N.Y.                             | Edw. Lee, Supt.           | 1903                 | Wrought Iron             | 20              | 80            | Ground                |                         | In open  | None          | None                          |                           |
| 2. LYNN, MASS.                                      | R.J. Newsom, Supt.        | 1895                 | Steel                    | 50              | 35            | Ground                |                         | Exposed  | None          | None                          |                           |
| 3. MASSENA, N.Y.                                    | St. Lawrence W. Co.       | 1908                 | Steel                    | 20              | 70            | Ground                |                         | Exposed  | None          | None                          |                           |
| 4. WINTHROP, MASS.                                  | L.R. Dunn, Supt.          | 1910                 | Steel                    | 40              | 100           | Ground                |                         | Exposed  | None          | None                          |                           |
| 5. CANTON, N.Y.                                     | L.R. Smith                | 1889                 | Wrought Iron             | 20              | 70            | Ground                |                         | Exposed  | None          | None                          |                           |
| 6. ABINGTON & ROCKLAND WATER WORKS, ROCKLAND, MASS. | Water Works               | 1896                 | Steel                    | 25              | 100           | Ground                |                         | Exposed  | None          | None                          |                           |
| 7. SOUTH PITTSBURGH, PA.                            | E.L. Keane, Mgr. W. Co.   | 1905                 | Cement                   | 50              | 100           | Ground                |                         | Exposed  | None          | None                          |                           |
| 8. JOPLIN, MO.                                      | A.B. Lynn, Wat. Dept.     | 1895                 | Steel                    | 25              | 150           | Ground                |                         | In open  | None          | None                          |                           |
| 9. ONSET, MASS.                                     | E.D. Eldridge, Supt.      | 1894                 | Steel                    | 20              | 40            | Tower                 | 63 ft.                  | Exposed  | None          | None (8)                      |                           |
| 10. CHICOPEE, MASS.                                 | Water Dept.               | 1893                 | Wrought Iron             | 55              | 60            | Ground                |                         | Exposed  | None          | None                          |                           |
| 11. LEXINGTON, MASS.                                | E.L. Locke, Supt.         | 1912                 | Concrete                 | 30              | 105           | Ground                |                         | Exposed  | None          | None                          |                           |
| 12. SAUGUS, MASS.                                   | A.F. Hart, Supt.          | 1913                 | Steel                    | 45              | 85            | Ground                |                         | Exposed  | None          | None                          |                           |
| 13. LINDSAY, ONT.                                   | Water Dept.               | 1890                 | Wrought Iron             | 16              | 110           | Stone found.          | 2 ft.                   | Exposed  | None          | None                          | No                        |
| 14. KINGSTON, ONT.                                  | C.C. Folger, Mgr.         | 1890                 | Steel                    | 40              | 80            | Stone found.          | 3 ft.                   | Exposed  | None          | None                          | No                        |
| 15. ST. JOSEPH, MICH.                               | Water Dept.               | 1892                 | Steel                    | 15              | 100           | (2)                   |                         | Exposed  | None          | None                          | No                        |
| 16. QUINCY, MASS.                                   | Water Dept.               | 1883                 | Wrought Iron             | 35              | 60            | Ground                |                         | Exposed  | None          | None                          | No                        |
| 17. WEYMOUTH, MASS.                                 | Water Dept.               | 1885                 | Wrought Iron             | 40              | 75            | Ground                |                         | Exposed  | None          | None                          | No                        |
| 18. BROCKTON, MASS. 1.                              | H. Kingman, Supt.         | 1890                 | Iron                     | 62              | 59            |                       |                         | Exposed  | None          | None                          | No                        |
| 19. BROCKTON, MASS. 2.                              | H. Kingman, Supt.         | 1905                 | Steel                    | 75              | 35            |                       |                         | Exposed  | None          | None                          | No                        |
| 20. ROCHESTER, N.Y. W. Co.                          | G.H. Biven, Supt.         | 1904                 | Steel                    | 150             | 20            | Conc. found.          |                         | (4)      | None          | None                          |                           |
| 21. RUTLAND, MASS.                                  | Water Dept.               | 1900                 | Wrought Iron             | 20              | 90            | Ground                |                         | Exposed  | None          | None                          |                           |
| 22. EAST ST. LOUIS, ILL.                            | C.M. Horner, Supt.        | 1896                 | Steel                    | 16              | 100           | Ground                |                         | Exposed  | None          | None                          |                           |
| 23. EDGE MOUNT, ST. LOUIS, ILL.                     | C.M. Horner, Supt.        | 1908                 | Steel                    | 65              | 30            | Ground                |                         | Exposed  | None          | None                          |                           |
| 24. MACLEOD, ALBERTA.                               | G.H. Altham, Supt.        | 1907                 | Steel                    | 22              | 40            | Tower                 | 92 ft.                  | In open  | None          | None                          |                           |
| 25. GREAT FALLS, MONT.                              | M.L. Morris, C.E.         | 1904                 | Steel                    | 40              | 60            | Ground                |                         | Exposed  | None          | None                          |                           |
| 26. LETHBRIDGE, ALBERTA                             | H.W. Meach, Com. Pub. W.  | 1909                 | Steel                    | 35              | 75            | Conc. found.          |                         | Exposed  | None          | None                          |                           |
| 27. BUFFALO, N.Y. 1. (WESTERN)                      | H.F. Huy, Gen. Mgr.       | 1903                 |                          | 40              | 80            |                       |                         | Exposed  | None          | None                          |                           |
| 28. BUFFALO, N.Y. 2. (NEW YORK)                     |                           |                      |                          | 25              | 50            |                       |                         | Exposed  | None          | None                          |                           |
| 29. BUFFALO, N.Y. 3. (WATER CO.)                    |                           | 1911                 |                          | 80              | 15            |                       |                         | Exposed  | None          | None                          |                           |
| 30. VILLE ST. LAURENT, ONT.                         | M. Marcel, Supt.          | 1905                 | Steel                    | 22              | 100           | Conc. base            | 9 ft.                   | In open  | None          | None                          |                           |
| 31. PORT ARTHUR, ONT.                               | L.M. Jones, City Eng.     | 1904                 | Steel                    | 25              | 65            | Ground                |                         | Exposed  | None          | None                          |                           |
| 32. ANTWERP, N.Y.                                   | C.F. Burdiss, Supt.       | 1895                 | Wrought Iron             | 20              | 50            | Ground                |                         | In open  | None          | None                          | No                        |
| 33. MT. VERNON, N.Y.                                | H.E. Walbert, Supt.       | 1886                 | Steel                    | 25              | 125           | Ground                |                         | Exposed  | None          | None                          | No                        |
| 34. MEDICINE HAT, ALBERTA.                          | R.B. Poyer, City Eng.     | 1900                 | Steel                    | 35              | 70            | Conc. base            | Ground level            | Exposed  | None          | None                          | No                        |
| 35. IRONWOOD, MICH.                                 | Water Works               | 1890                 | Wrought Iron             | 50              | 50            | Ground                |                         | Exposed  | None          | None                          |                           |
| 36. ST. JOSEPH, MO.                                 | C.H. Taylor, Supt.        | 1900                 | Steel                    | 50              | 55            | Ground                |                         | Exposed  | None          | None                          |                           |
| 37. SENECA FALLS, N.Y.                              | Water Dept.               | 1900                 | Steel                    | 30              | 100           | Ground                |                         | In open  | None          | None                          |                           |
| 38. PEMBROKE, ONT.                                  | J.P. Howe, Town Eng.      | 1893                 | Steel                    | 20              | 60            | Ground                |                         | Exposed  | None          | None                          |                           |
| 39. MARINETTA, WIS.                                 | Water Dept.               | 1912                 | Steel                    | 40              | 20            | Ground                |                         | Exposed  | None          | None                          |                           |

(1) Wood fastened to steel braces attached to pipe, 2 ft. air space. (2) Foundation top level with the street grade. (3) 7  
(5) Brick tower stone trimmed supports roof (6) In 1914 8" brick wall 2" air space, paper and asphalt lining; sealed top and  
(8) Tank unprotected but tower of hard pine entirely encased. (9) Partly but also protection against frost. (10) Partly to prevent  
adjacent firehail applied to vertical pipe for frost protection Nov 15 to Mar. 15 (11) 2 1/2 foot platform around outside of top  
of standpipe to break up the ice (12) Waste water to distribution mains and refill, water fluctuates.

20 FROM AND BY THE COURTESY OF THE WATER WORKS SUPERINTENDENTS.

the street grade. (3) Three sides exposed, North protected by buildings. (4) Exposed, sheltered same by trees. (5) Half lining, sealed top and weep holes. (7) Recently sold to Alberta government; now erected and in use at Red Deer, Alberta. (8) Partly to prevent spalling of concrete. (1) Architectural effect combined with service. (2) Steam line from old-form around outside of top; overflow freezes to this, have seen ice 18" thick in pipe. (14) Row of spikes 6 ft. from top of inside flanges.

and more or less all around. The top ice is moving either up or down all the time and breaks into cakes, and rolling around they grow bigger, some 3 feet, some smaller.

*St. Joseph Water Company, Missouri; C. H. Taylor, Superintendent.* The standpipe at the reservoir is used very seldom and only in case of fire. When the weather becomes cold enough to form ice on the standpipe, we at once open the by-pass around the check valve and permit the water in the standpipe to waste into our distribution mains, the rate of flow of the water through this by-pass depending on the temperature.

The lowering of the water in the standpipe keeps the ice cake on top of the water constantly broken up into small cakes and slush ice, this being a 50-foot diameter by 55-foot high standpipe. In extreme weather we permit the water to waste out of the standpipe until perhaps we have lowered the head from 10 feet to 15 feet from the point where we started. We then pump water into the standpipe, bringing it again up to the top of same or to the overflow and usually during extreme weather we are obliged to refill the standpipes weekly. The only precaution necessary to protect the standpipe from damage during cold weather is to keep lowering the water in same sufficiently rapidly to prevent the surface freezing solid enough that the surface cake will break when the water level is lowered underneath same. It is also very essential when the standpipe is ringed with heavy ice not to permit the water to lower too far at a time when the temperature is rising for fear that this inside lining of ice when very heavy will fall, in so doing, cause undue strain on the structure of the standpipe.

*St. Joseph Water Works, Michigan; F. A. Bunks, Superintendent.* We have had the ice shoot up over the top of the pipe in the spring time, due to the station allowing the water in the pipe to rise above the danger point.

We have had trouble with the ice when we try the policy of pumping the standpipe full of water and then shutting down the pumps until the pressure dropped sufficiently. We have for the last 5 years maintained an even water level in the pipe during the winter (or as nearly level as possible) with the result of no trouble with the ice. Domestic pressure is 40 pounds per square inch. For fire we cut out the standpipe and pump direct, with a fire pressure of 80 pounds.

*Menasha Water Works, Wisconsin; John H. Knester, Superintendent.* We installed an 1800 gallons per minute centrifugal (pump) this winter that held the head too steady and ice formed on top of water; also our riser pipe froze solid and split four lengths, 48 feet, which we have just renewed at a cost of over \$500. I believe in our case that we will cover riser pipe with felt frost covering and I think we ought to put in a hot water boiler of about 500 feet radiation capacity in which to burn hard coal, this to keep riser pipe open and to keep ice from forming on top of water and keep ice from getting too thick around shell; this heater to be connected to a tap at lowest point of riser pipe and also just above boiler. This will give circulation down to below frost level. This arrangement will cost less in operation and maintenance than going to extremes in cost for frost coverings and housing. . . . If we don't put in some sort of heating we will have to drain tank and piping and lose the advantage of storage for emergency.

*Manistique Water Works, Michigan;* H. Eriksen. During the winter months, about once a week we cut out the ice formed in standpipe (which formation begins at the inlet to the tank) in the following manner:

We close the valve at one side of the tank and open the valve opposite it, which permits the water in the riser and standpipe to empty into a sewer. The force of the moving water very effectually clears out any and all ice that may have formed, either in the standpipe or riser. This operation takes about 25 minutes.

*Milwaukee Water Works, Wisconsin;* H. P. Bohmann, Superintendent. At the North Point Pumping Station standpipe, we have no ice trouble in moderate winter weather, as the fluctuation of the water in the standpipe keeps the ice broken. When the temperature is at zero or below, ice at times becomes solid and just as soon as it begins to get solid, a pail of salt is dumped on the ice which eats through the ice in a very short time. The formation does not give us trouble, as it gradually melts in early spring.

At the High Service Pumping Station, the greater fluctuation of water keeps it open most of the time, otherwise salt is introduced in the same manner as at the North Point Pumping Station. . . . Where the salt eats through the ice I should judge it is anywhere from 2 inches to 6 inches in thickness, tapering down to nothing. The distance from the top of the ice to where it tapers away is anywhere from 10 to 15 feet.

By keeping an opening with salt, we have avoided ice troubles at all times.

With respect to additional cost of from 50 to 100 per cent for encasing or covering a standpipe he says:

It would be justified in this city as bare standpipes are not ornamental and our standpipes are located in a fine residential district.

*Port Arthur, Ontario;* L. M. Jones, City Engineer. We have a standpipe here and have also encountered some ice troubles.

Our standpipe is 25 feet in diameter by 65 feet high and holds approximately 200,000 imperial gallons. It is built of steel and was constructed in 1904. It is situated on the highest ground in the city and rests on a concrete foundation supported by solid rock. The top is 278 feet above the supply level. When it was built, the base was at a considerably higher elevation than any other building, but since then the residential portion of the city has grown considerably in the direction of the hill top, so that there are now a large number of houses on the same level as the base of the standpipe. One large house and a school have the plumbing fixtures located at an elevation about 30 feet above the standpipe base.

When the standpipe was first built the population was small and the system of piping new. The pumps were operated through the day and after midnight were closed down, the consumers being supplied from the standpipe. In this way the water was changed daily at least. As the population and number of consumers grew and the system increased, the pumps were kept in service longer during the day, but they struggled to keep water on the hill top, the consequence being that the water level in the standpipe kept fluctuating to such an extent that the water was continually changing.

During these periods we had no trouble with ice. The writer remembers seeing the ice 2 or 3 feet above the top of the standpipe, floating in the water, but this was in the spring after it had loosened from the sides.

Later on, the city grew in all directions and the standpipe had to be kept full nearly all the time to ensure a supply at reasonable pressure to the consumers in its immediate vicinity. Also a power sub-station was located quite near it and this had to be protected from overflowing. In the old days when there were no houses near, it did not matter if it did overflow. But subsequent development would not permit this.

New pumps were installed at the main pumping station and a booster pump was set in the system half way up the hill to help out for fire fighting. This booster was automatically controlled. A Golden-Anderson altitude valve was placed on the inlet to the standpipe. When the water dropped in the standpipe to a level 12 feet from the top, the pump cut in and filled the standpipe, or the valve can be closed at any water level. Our new pumps at the main station were of greater capacity than actually required at present and the standpipe was therefore kept full nearly all the time. In short, there was very little changing of the water, with the result that the standpipe froze over solid and the sides were lined with ice about 4 feet in thickness. We first noticed trouble when the water receded from the ice and gave us trouble with the controlling mechanism of the booster pump, probably due to vacuum conditions set up between the water level and the ice level. At any rate when we cut a hole in the ice the trouble disappeared. I may say that there was quite a rush of air when the hole was cut. For the balance of the winter (1914 and 1915) we kept the ice clear of the top of the standpipe.

The following winter we cut the standpipe off the system entirely but experienced considerable trouble, as it proved to be quite a balancing feature on the system.

We have since that time kept it on the system but have not allowed it to freeze over solid, but keep a hole about 12 feet in diameter at the center of the ice covering. This requires attention about twice a week, but we get no other trouble.

My opinion is that to get the best service, the standpipe should be completely housed in and some degree of heat be introduced to keep the water from freezing. A standpipe is constructed of a capacity sufficient to perform a certain duty. It is questionable if the reduced storage capacity (in our case it is reduced 50 per cent or more) due to ice formation is ever considered. In our country the ice condition prevails at least five months in each year or nearly 50 per cent of the time. In order to get the maximum benefit of the expenditure, the cost should be increased to secure a proper covering and thus receive 100 per cent return for the investment. Aside from this there is always the serious danger due to the expansive effect of ice on a structure of this kind.

*Humbolt Water Works, Saskatchewan; C. A. Cutting, Superintendent.* Contemplate drawing about 50 gallons per minute from condenser basin and pumping into tower, the more gradual the better, to minimize contraction and expansion of joints in pipe.

. . . . . Allow the level to remain at 60 feet, then increase to 70 feet, which melts ice which is under water. If tower is kept full all the time no op-

portunity is afforded for temperature in newly pumped water to act on ridge of ice.

Also divide pumping up, say, over 4-hour periods.

*Saskatoon Water Works, Saskatchewan;* C. A. Cutting, Chief Engineer (formerly). A 250-horsepower boiler was fired and a 2-inch steam pipe let loose at about 100 pounds pressure without avail. Previous to this, city water was pumped through a small condenser of 400 feet surface.

*North Battleford Water Works, Saskatchewan;* M. D. Cadwell, Superintendent. The writer has had twenty years experience in the West with water systems and is fully convinced that any tower unhoused is entirely unsuitable for a climate such as prevails in Western Canada during the winter months.

No trouble due to fact that tower is completely housed and further to the fact that our water system is supplied with warm water, the initial temperature of which is approximately from 60° to 70°, usually from the last day of February to the end of March or later, as the conditions may require.

Prior to the commencement of the warm water supply, which is taken from the cooling basin at the power plant, we always found a quantity of ice floating on the water in the standpipe. To the best of the writer's knowledge, the same has never adhered either to the wall surface in any quantity nor has it become lodged at the top of the tower, but has always floated on the surface of the water.

The writer understands that a number of towers have been wrecked due to the fact that the ice adhered to the walls or the top of the tower and fell, due to increased temperatures, when the water was at a low elevation in the tower.

#### CONCLUSIONS BASED UPON RECORDS SUBMITTED

1. Open standpipes have been operated successfully in the northern United States by water works having surface, as well as by those having ground-water supplies, in spite of some trouble due to the formation in them of ice during the cold winter months.

2. This statement is true also of some water works in Canada, though its climate makes the covering of standpipes more generally necessary than in the northern United States.

3. Past failures of standpipes have been frequent and serious enough, however, to make careful consideration or analysis of conditions of location, exposure, method of operation, circulation and variation in rate of water demand, desirable, with a view to determining whether the financial condition of the works will justify the encasing or roofing of the standpipe, make necessary the assumption of the hazard of difficulties or injury to be anticipated from ice formation, or compel the abandonment of the idea of the use of a standpipe.

4. Structures within the standpipe, such as ladders and overflow pipes, are to be avoided, as they are likely to be torn down by the floating ice sheet.

5. Heavy variation in demand inducing good circulation within the standpipe generally minimizes the formation of ice. The maintenance of a water surface substantially below the top of the standpipe seems to tend in the same direction. But when a heavy ice sheet has formed on top, practical experience or perhaps fear of trouble has led superintendents to try to maintain the water level as nearly constant as possible, particularly when the melting of the ice sheet is expected, in order to prevent the fall of a heavy mass of ice into the water below it, with piston-like shock and imminent danger of collapse of the entire structure.

6. With increase in diameter over 30 to 40 feet, troubles from ice appear to decrease. Often they do with standpipes of smaller diameter, though probably for different reasons.

7. In extreme cases salt has sometimes, though rarely, been used on the surface of the ice sheet, to keep it open; holes have also been chopped in it to prevent suction from being developed between the ice sheet and the dropping water column, which would tend to cause the fall of the ice. In Canada the expedient of pumping some condenser water into the standpipe, to raise the temperature of the supply, has also been used successfully.

8. Usually the warmer incoming water at the bottom of the standpipe tends to prevent the formation of ice at this point, or even in the lower part of the structure.

9. In extreme cold, ice often forms in a cylinder around the inside of the standpipe, as well as in a sheet covering the water surface in the standpipe.

10. There is substantial danger from the partial melting of the ice cylinder on the southerly side of the standpipe, under the warmth of the rays of the sun and from the refreezing of the water thus melted, held between the steel shell of the standpipe and the vertical annular ice cylinder within it, with undesirable if not dangerous expansive force.

11. Ice is reported to have projected above standpipes from 10 to 20 feet in extreme cases. These amounts seem almost incredible, but at least one photograph is available showing the projecting column of ice to have been nearly equivalent to two rows of plates, or 10 feet in height, above the top of the structure. This case

developed on the south shore of Lake Michigan in a standpipe 16 feet in diameter and 100 feet high. How far down it extended under those conditions, is unknown. The danger to the structure inherent in the fall of such a slug of ice is obvious.

12. A heavy ring of ice near the top of the standpipe, with solid sheet of ice covering it, is common even when the vertical cylinder of ice next the wall of the structure tapers rapidly toward the bottom.

13. The roofing of the standpipe (without encasement of its walls) seems to have been generally effective in preventing the formation of a heavy ice cylinder or floating ice sheet within the standpipe, particularly where ground water supplies are used. The fact that a greater percentage of standpipes supplied with ground rather than with surface water have been roofed may be due to the greater need of excluding sunlight from ground water, to prevent the growth of algae.

14. The complete covering of the structure, leaving a space of 30 inches or more between the standpipe shell and the encasing material, for painting, is the most effective and desirable protection against trouble with ice in exposed northern sites, particularly where the water is cold, the circulation slight and the financial considerations involved are not prohibitive. The application of heat is sometimes resorted to in the coldest weather, to prevent freezing of the riser pipe, where the standpipe is elevated.

15. With reference to the age of these standpipes the following notes may be of interest. Of the 118 tanks the ages of which are known, 64 per cent are of steel, 20 per cent wrought iron, 12 per cent reinforced concrete, 4 per cent of wood. The ages of the steel tanks range from 4 years to 30 years, the average age being 17 years. The ages of the wrought iron tanks range from 17 years to 48 years, the average age being 31 years. The age of the reinforced concrete tanks is from 6 years to 20 years, the average being 11 years. The age of the wooden tanks is from 7 years to 30 years, the average being 23 years. In interpreting these results it is to be borne in mind that the wrought iron is the oldest material used; that steel came into general use at a slightly later date, and that the use of reinforced concrete for standpipes is of comparatively recent origin. The data concerning the wooden tanks are not sufficiently complete to be of significance.

# ADDENDUM

Since compiling the tabulation upon "Experiences with Ice in Standpipes" the following interesting information has been received from Mr. S. E. Killam, Superintendent of Pipe Lines and Reservoirs, Water Division, of the Massachusetts Metropolitan District Commission, relative to three of its standpipes, all of which receive their water from surface supplies.

|   | "ARLINGTON" AT<br>ARLINGTON<br>HEIGHTS | "BOSTON" AT<br>AT BELLEVUE<br>HEIGHTS                    | "QUINCY"<br>ON FORBES HILL  |
|---|--|--|---|
| Date of construction (approximate).....   | 1894                                   | 1914   | 1900  |
| Material.....   | Wrought iron                           | Steel  | Steel   |
| Diameter (feet).....  | 60                                     | 100  | 30  |
| Height (feet).....  | 40                                     | 44   | 64  |
| Foundation.....   | Masonry base                           | Masonry base   | Masonry base  |
| Position.....   | Exposed                                | Exposed  | Exposed   |
| Kind of roof.....   | Conical, resting on standpipe          | Masonry; is observation roof of tower                    |   |
| Method of encasement.....   | None                                   | Masonry tower with 4 ft. space; wall 3 ft. thick at base | Masonry tower with 3.25 ft. space; wall 4.75 ft. thick at base and 2 ft. at top below cornice |
| Was encasement designed for architectural effect only?.....                           |  | No   | No  |
| Is standpipe cut out of service in winter?.....                                       | No                                     | No   | No  |
| In <i>ordinary</i> weather how thick does ice form on top of water in standpipe?..... | 6 to 8 in.                             | 2 to 4 in.   | 2 to 4 in.  |
| On inside of shell?.....  | None                                   | None   | None  |
| In <i>extreme</i> weather how thick does ice form on top of water in standpipe?.....  | 8 to 12 in.                            | 5 in.  | 6 in.   |
| On inside of shell?.....  | None                                   | None   | None  |

|  | "ARLINGTON" AT<br>ARLINGTON<br>HEIGHTS | "BOSTON"<br>AT BELLEVUE<br>HEIGHTS | "QUINCY"<br>ON FORBES HILL |
|--|--|------------------------------------|----------------------------|
| Has ice frequently projected<br>above standpipe?.....  | No                                     | No                                 | No                         |
| Is artificial heat ever applied?..   | No                                     | No                                 | No                         |
| Has standpipe ever suffered se-<br>rious injury from ice? .....  | No*                                    | No*                                | No*                        |
| Do you think under conditions<br>of your works an additional<br>cost for encasing of from 50 to<br>100 per cent of cost of stand-<br>pipe itself, is justified?..... | Yes                                    | Yes                                | Yes                        |

\* Although interior coating has been injured by movement of ice.